Battlefield Orthopaedic Injuries Cause the Majority of Long-term Disabilities

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Abstract

Extremity injuries make up 54% of combat wounds sustained in Operation Iraqi Freedom and Operation Enduring Freedom. In a cohort of war-wounded service members, we identified the conditions secondary to battle injury that result in disqualification from continued service. The Army Physical Evaluation Board records of 464 wounded service members who were injured between October 2001 and January 2005 were reviewed to determine the codes indicating unfitting conditions. Sixty-nine percent of these conditions were orthopaedic. Fifty-seven percent of the injured had unfitting conditions that were orthopaedic only. Of those evacuated from theater with a primary diagnosis of injury to the head, thorax, or abdomen and who suffered an orthopaedic injury as well, 76% had an orthopaedic diagnosis as the primary unfitting condition. Orthopaedic-related disability has a significant impact on the affected patient, the health care system, and, in the case of wounded service members, on military strength and readiness.

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This study was conducted under a protocol reviewed and approved by the Brooke Army Medical Center Institutional Review Board, and in accordance with good clinical practices. The opinions or assertions contained herein are the private views of the author and are not to be construed as official or as reflecting the views of the Department of the Army or the Department of Defense.

J Am Acad Orthop Surg 2011;19 (suppl 1):S1-S7

Most wounds sustained by service members serving in Operation Enduring Freedom (OEF) and Operation Iraqi Freedom (OIF) are extremity injuries.[1,2] These injuries account for approximately two thirds of initial hospitalization costs and estimated disability payments.[3] However, characterization of specific disabling conditions resulting from combat injuries has never been studied. Combat casualty care has improved with better understanding of wounding patterns, and long-term care of combat casualties would benefit from enhanced understanding of the long-term disability caused by these wounds. This is especially critical as the US Department of Veterans' Affairs (VA) prepares to care for the current generation of combat veterans. This information will also be helpful in prioritizing future research funding.

The US Army Physical Evaluation Board (PEB) is a convening body of army officers and medical personnel who are responsible for determining whether an ill or injured service member is able to continue serving on active duty. Those who are wounded during combat operations receive medical care until a state of maximum medical benefit has been reached. Those who are capable are returned to active duty. However, if the medical provider feels that return to active duty is not possible, the service member is referred to the PEB to determine whether permanent disability exists that would preclude active duty service. The PEB relies on

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
01 FEB 2011	**N/A**	**-**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Battlefield orthopaedic injuries cause the majority of long-term disabilities	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
Cross J. D., Ficke J. R., Hsu J. R., Masini B. D., Wenke J. C.,	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)	8. PERFORMING ORGANIZATION REPORT NUMBER
United States Army Institute of Surgical Research, JBSA Fort Sam Houston, TX	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**UU**	**7**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

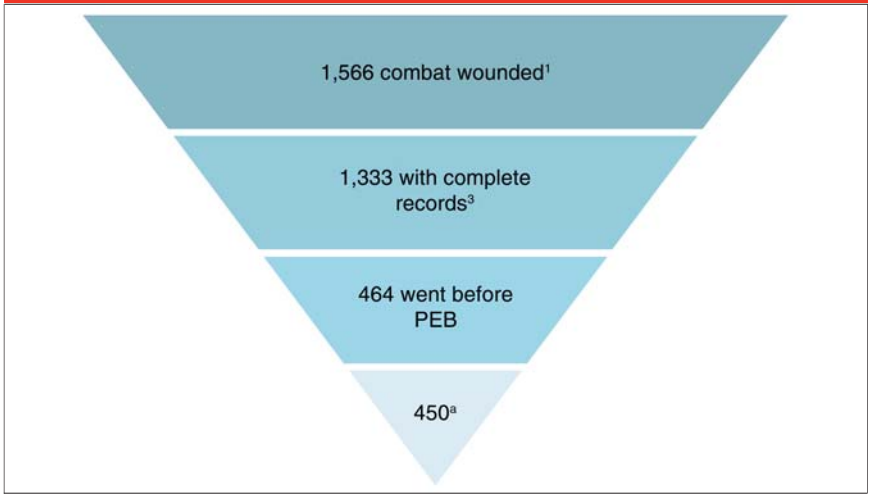
the full medical evaluation information to determine whether a service member is fit for duty, may return to active duty in a limited capacity or under a different occupational requirement, or is unfit and must be disqualified from continued service. The service member with an unfitting condition is medically retired, and a percent disability rating is determined based on the impairment of each unfitting condition. This percentage determines eligibility for disability benefits.

To further understand the disabling impact of battlefield orthopaedic injuries, we identify the unfitting conditions that prevent return to active duty, and we characterize the frequency and severity of these conditions at the time of medical discharge. The wounds that necessitate evacuation from combat operations are not necessarily the wounds that ultimately result in long-term disability. The disabling conditions resulting from battlefield orthopaedic injuries lead to most unfitting conditions and have a greater impact on permanent disability than previously thought.

Methods

The patient cohort for this study is adopted from a previously published cohort of combat-wounded US service members evacuated from OEF and OIF and entered into a military casualty database.[1] A query in the Joint Theater Trauma Registry identified 3,102 casualties entered consecutively between October 2001 and January 2005. Of these, 1,566 were wounded in action and did not return to duty within 72 hours. Complete records were available for resource utilization analysis for 1,333 persons in that group.[3] Four hundred sixty-four of the 1,333 service members were formally evaluated for permanent physical disability by the PEB. PEB disability information was available for 450 of these 464 patients. Five were found to be fit for duty, and nine had died while on the temporary disabled retirement list. These 450 service members make up the present cohort (Figure 1).

Figure 1



Visual representation demonstrating the path to arriving at the number of wounded service members studied for long-term disability. PEB = US Army Physical Evaluation Board. [a] With complete PEB records.

The PEB database was searched for board results on each person; codes of unfitting conditions and the percent disability determined for each condition were captured. The PEB results listed included fit for duty, continuation on active duty in a limited capacity, placement on a temporary disabled retirement list, separation from the service with severance pay, or permanent medical retirement. The codes used by the PEB are those used in the published Veterans Affairs Schedule for Rating Disabilities (VASRD).[4-7] A VASRD formula was used to calculate the overall percent disability from the disability assigned to each code. Once the PEB results and VASRD codes were identified for each service member, the VASRD codes were linked to clinical diagnoses that contributed to the unfitting condition. Each unfitting condition was sorted into a category consistent with the VASRD groups (Tables 1 and 2).

Each narrative summary in the service member's PEB record was reviewed. The narrative summary includes thorough documentation of

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Table 1

Musculoskeletal Unfitting Conditions in Combat-injured Service Members

Condition	Description
Extremity scarring	Extremity scar from any cause in which the scar itself is unfitting
Pain	Extremity pain at the site of an injury not due to joint or nerve pain
Degenerative arthritis	Joint pain, loss of range of motion, or radiographic evidence of arthritis
Osteomyelitis	Infection of bone where infection itself is unfitting
Muscle condition	Loss of muscle mass causing weakness
Nerve: Loss of function	Nerve injury causing loss of terminal organ function, including loss of sensation
Nerve: Pain	Dysesthesia or pain resulting from nerve injury without loss of function
Back pain	Pain caused by injury to the spine, paraspinal musculature, or intravertebral disk but excluding the spinal cord
Spine	Partial or complete spinal cord injury
Hand condition	Dysfunction of the hand, including loss of finger motion and single finger amputation
Upper extremity amputation	Amputation, from shoulder disarticulation to multiple fingers of the same hand
Lower extremity amputation	Amputation, from hip disarticulation to midfoot

Table 2

Nonmusculoskeletal Unfitting Conditions in Combat-injured Service Members

Anatomic Area or Condition	Description
Head	Any anatomic injury to the head (eg, skull defects, loss of brain matter)
Ear	Any condition affecting hearing
Eye	Any condition affecting ocular motion or sight
Face	Facial scarring or disfigurement
Chest	Injury to the chest or the thorax or other medical diagnoses that affect the heart and lungs
Abdomen/Pelvis	Injury to abdominal or pelvic organs or medical diagnoses that affect the abdominal and pelvic organs
Posttraumatic stress disorder	Diagnosis of posttraumatic stress disorder
Traumatic brain injury	Cognitive impairment resulting from head injury, traumatic brain injury

patient history and physical examination performed by the medical care provider during the impairment evaluation. For battlefield-injured service members, the documentation includes details on the injuries, the recovery process, and residual impairments from the wounds. Other demographic data collected from the PEB record include mechanism of injury, theater of operation, age, and rank at the time of injury.

The frequency of unfitting conditions and the average percent disability for each category were calculated. The cohort impact for each unfitting condition was determined by multiplying the average percent disability by the frequency for each group. For orthopaedic-related unfitting conditions, data were further classified by the affected anatomic region.

Results

The typical medically retired service member is a young enlisted man injured in an explosion, a demographic similar to previous descriptions of battlefield-injured personnel (Tables 3 and 4). Degenerative arthritis was the most common unfitting condition (Table 5). Upper limb amputation was associated with the greatest average percent disability (Table 6). Lower extremity amputation, given its incidence and relatively high corresponding average percent disability, had the highest impact (Table 7). Of all unfitting conditions, 70% were orthopaedic (Figure 2).

Of the 450 persons studied, 377 (84%) had at least one orthopaedic-related unfitting condition. Two hundred fifty-nine were found to be unfit for duty solely because of orthopaedic conditions. Injuries to the leg and thigh were the most numerous (83 and 66, respectively) and caused the greatest number of unfitting conditions (89 and 78, respectively). Unfitting conditions related to the arm were associated with the highest percent disability (Table 8). The elbow had the most unfitting conditions per injury. Soft-tissue injury, fracture, and nerve injury were the most common types of injury, and pain, loss of nerve function/sensation, and loss of joint motion were the most common outcomes (Table 9). Of the 359 ser-

Table 3

Cohort Demographics of US Service Personnel Wounded Between October 2001 and January 2005

Demographic Factor	Owens et al[1]	Present Cohort
Average age	26	26.3
Percent male	97%	96%
Median rank	E-4	E-4
Percent enlisted personnel	94%	96%
Percent by component (Active duty / National Guard / National Reserves, respectively)	Not reported	76% / 17% / 7%

Table 4

Mechanisms of Injury by Study

Mechanism of Injury	Owens et al[1] (%)	Present Cohort (%)
Explosion	79	75
Gunshot wound	19	20
Motor vehicle collision, helicopter crash, fall	2	5

Table 5

Ranking of Unfitting Conditions by Frequency

Rank No.	Unfitting Condition	Frequency
1	Degenerative arthritis	135
2	Nerve: Loss of function	102
3	Posttraumatic stress disorder	101
4	Pain	59
5	Lower extremity amputation	56
6	Back pain	54
7	Eye condition	45
8	Traumatic brain injury	43
9	Hand condition	42
10	Muscle condition	39
11	Extremity scarring	35
12	Spine condition	32
13	Abdomen/pelvis condition	28
14	Nerve: Pain	27
15	Head condition	25
16	Upper extremity amputation	25
17	Face condition	12
18	Chest condition	9
19	Ear condition	6
20	Osteomyelitis	2

vice members with complete records, 112 were evacuated from theater primarily due to injury sustained in the abdomen, thorax, or head. Of these 112, 85 were unfit primarily because of an orthopaedic condition at the time of the PEB (Table 10). In this subgroup, 72% of total-percent disability was related to an orthopaedic unfitting condition.

Discussion

Long-term care of combat casualties would benefit from enhanced understanding of how combat injuries lead to permanent disability. Current applications of combat casualty care and planning for longer-term demands on the VA system depend on knowing which conditions persist following successful management of acute injury. We have provided a descriptive analysis of the unfitting conditions resulting from battle injuries that disqualify persons from continued service in a representative cohort of wounded service members and demonstrated that orthopaedic-specific conditions contribute heavily to permanent disability. Our findings are consistent with those of studies performed in civilian multitrauma populations. These studies have demonstrated that extremity injuries are among the most, if not the most, important influence on long-term outcome and return to work.[8-10] The predominant influence of extremity injury on long-term disability persisted in wounded services members who were admitted with a primary diagnosis in other anatomic regions.

The cohort we studied, based on demographic information and injury mechanism, represents long-term disability outcomes of the group previously studied by Owens et al.[1] The Owens cohort adequately represented the total combat-wounded population for the period studied. Our study may likewise be extended to the overall impact of disability resulting from the current conflicts. Masini et al[3] demonstrated that 35% of battle-injured and evacuated service members were placed before the medical board. Of these, only 1% were able to return to duty. These percentages show that battle injuries are permanently decreasing US fighting strength.

Masini et al[3] were the first to document the high cost of hospitalization and disability resulting from combat injuries. Their study demonstrated the tremendous resources required to manage extremity injuries. Although extremity injury accounted for 54% of all wounds, these injuries required 64% of resource utilization. However, this study relied on several as-

Table 6

Ranking of Unfitting Conditions by Average Percent Disability

Rank No.	Unfitting Condition	Average Percent Disability
1	Upper extremity amputation	72
2	Spine condition	60
3	Lower extremity amputation	56
4	Head condition	49
5	Abdomen/pelvis condition	38
6	Eye condition	35
7	Face condition	33
8	Chest condition	32
9	Nerve: Loss of function	31
10	Hand condition	26
11	Muscle condition	25
12	Traumatic brain injury	23
13	Posttraumatic stress disorder	19
14	Extremity scarring	18
15	Osteomyelitis	15
16	Degenerative arthritis	15
17	Nerve: Pain	13
18	Pain	12
19	Back pain	12
20	Ear condition	8

Table 7

Ranking of Unfitting Conditions by Impact

Rank No.	Unfitting Condition	Impact[a]
1	Lower extremity amputation	3,150
2	Nerve: Loss of function	3,130
3	Degenerative arthritis	2,000
4	Spine condition	1,930
5	Posttraumatic stress disorder	1,930
6	Upper extremity amputation	1,795
7	Eye condition	1,570
8	Head condition	1,220
9	Hand condition	1,090
10	Abdomen/pelvis condition	1,050
11	Muscle condition	990
12	Traumatic brain injury	970
13	Pain	730
14	Back pain	623
15	Extremity scarring	620
16	Face condition	390
17	Nerve: Pain	340
18	Chest condition	290
19	Ear condition	50
20	Osteomyelitis	30

[a] Frequency × average percent disability

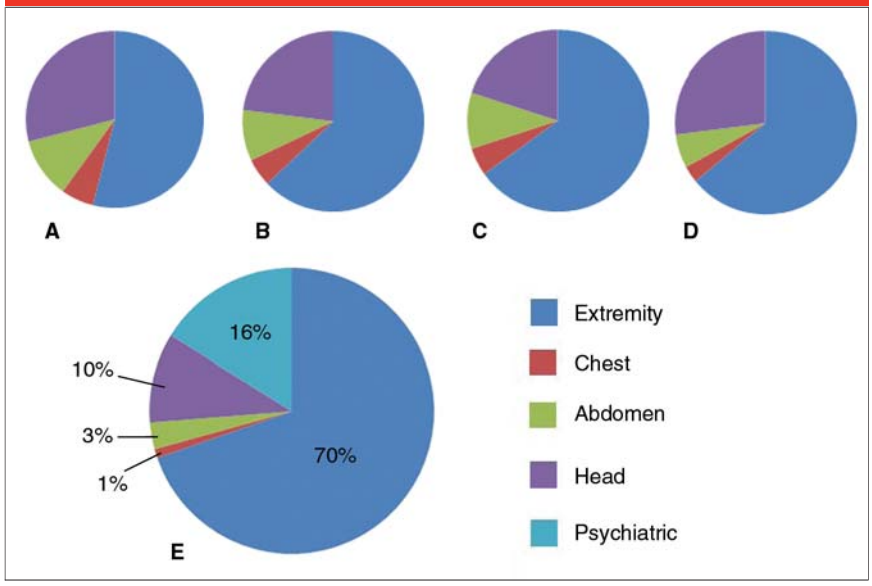
sumptions that suggested that the impact of extremity injury was still being underestimated. At the time of the study by Masini et al,[3] the PEB data for each injury were not accessible; thus, disability calculations were assigned to the anatomic region associated with the primary diagnosis for each respective hospital admission, which generally correlated with the primary diagnosis that necessitated evacuation from theater. Although the primary reason for evacuation from theater may be related to a primary injury to the abdomen, thorax, or head for some service members, the majority ultimately have a primary orthopaedic disqualifying condition (92%, 92%, and 56%, respectively). Thus, the cost of disability noted in the study by Masini et al[3] that was attributed to extremity injury was slightly underestimated (69% versus 64%). A 5% difference may seem small, but that difference represents an underestimation in financial impact of orthopaedic disability benefits of $95 million.

The final disability attributed to head, thorax, and abdominal injuries is also inflated by eliminating psychiatric conditions. To our knowledge, ours is the first study to delineate specific conditions found at the final evaluation of physical disability. We demonstrated that psychiatric conditions make up 16% of permanent disability. We also demonstrated that the residual conditions from abdominal and chest injuries are far less frequent than previously thought. This finding suggests that those who survive abdominal and chest injuries are likely to make a complete or near complete recovery from these injuries. Head-injured patients account for approximately 29% of overall injury frequency and 20% of resource utilization. However, the effect of head injury remains high; 44% of the patients evacuated for a head injury have a head-related unfitting condition as the primary contributor to overall percent disability. The overall impact of extremity injuries is not as proportionally great in the head-injured patient, but extremity injuries account for most disabilities in head-injured patients (Table 10).

The breakdown of injuries by anatomic region has not previously been published in such detail. It is notable that some injury sites, such as the elbow, tend to be related to more than one unfitting condition per injury. This is not unanticipated, however. For example, elbow injury is commonly associated with nerve disability, elbow stiffness, and pain, each of which can cause disability. Lower extremity injuries make up the largest percentage of injury numbers (249 of 438) and unfitting conditions (275 of 502). Most injuries in these conflicts are caused by explosive projectiles; the lower extremities are usually most exposed to the shrapnel, and they account for the greatest body surface area.

This retrospective study offers a longitudinal account of an original large cohort, with high correlation of records as well as subject identification. Ours is the first effort to clas-

Figure 2



Incidence of injury (**A**), primary admission diagnoses (**B**), resource utilization (**C**), and projected disability costs (**D**) of combat-related unfitting conditions by region of the body. **E,** Unfitting conditions by region of the body.

Table 9

Number of Injury Types and Outcomes in Service Members With Combat-related Unfitting Conditions

Injury Type	
Fractures	198
Soft-tissue injury	247
Amputation	82
Nerve injury	122
Vascular injury	12
Posttraumatic stress disorder	69
Outcomes	
Pain	294
Loss of joint motion	107
Muscle, tendon, or ligament insufficiency	70
Loss of nerve function and/or sensation	131
Infection	23
Fracture nonunion	11

Table 8

Combat-related Orthopaedic Injuries by Anatomic Region

Anatomic Region	No. of Injuries	No. of Disabling Conditions	Average % Disability
Leg	83	89	26
Thigh	66	78	33
Spine	64	73	27
Forearm	49	59	31
Shoulder	40	42	23
Knee	37	39	14
Arm	31	31	48
Hand	30	39	21
Hip/Pelvis	24	27	30
Elbow	23	38	21
Ankle	23	23	20
Foot	16	19	21
Wrist	16	18	16

sify the unfitting conditions resulting from the current conflicts. The same group of combat casualties has been followed longitudinally from injury characterization to primary diagnosis at time of evacuation; we know the hospital costs associated with initial treatment and, now, the unfitting conditions that persisted after adequate treatment. Despite the general completeness of the PEB records, this study was subject to the limitations inherent in any record review. The narrative summary on which much of the clinical diagnoses for each unfitting condition were determined was often supplemented by an orthopaedic surgeon's addendum, but this was lacking in some cases, which limited our ability to classify the injury specifics any further.

These data are relevant to the civilian community, as well. Trauma is the second most expensive health care cost; it is responsible for nearly $300 billion per year in lost wages and productivity.[11] Several studies have demonstrated that the sequelae of extremity injuries limit the ability of multiply-injured patients to return to work.[12-14] Furthermore, complications related to their orthopaedic care may drive a poor overall health status outcome.[15,16] The recent earthquake in Haiti highlights the burden of extremity injuries that can occur from a natural disaster. Handicap International estimates that >85% of injuries in the earthquake survivors are orthopaedic in nature (ie, fracture, amputation).[17] It is difficult to predict the long-term disability and

Table 10

Primary Indications for Medical Evacuation From Combat Theater Versus Primary Disability

Injury Type	No. Evacuated	No. With Primary Disability Due to Orthopaedic Injury	Orthopaedic Primary Disability (%)
Extremity	247	247	100
Abdominal	37	34	92
Chest	25	23	92
Head	50	28	56

financial impact resulting from these injuries on Haiti's economy.[17]

It is important to know which conditions prevent the return of service members to active-duty service. The battle-related injuries serve as force subtractors that reduce combat effectiveness and result in lifelong disability. Further investigation is required to reduce disability and preserve the ability of US service members to serve the nation.

Summary

Investigations into wounding characteristics, resource utilization, and the specific injuries that ultimately disqualify service members from active duty demonstrate that musculoskeletal injuries are the most common and the most costly and that they create the greatest loss of fighting strength. Data on the civilian burden of musculoskeletal injury parallels our findings with respect to frequency of injury, resource utilization in total bed days, and disability in lost work days.[18] Continued efforts are required to improve outcomes in orthopaedic care of musculoskeletal injuries.

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